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AUTHOR Shimron, Joseph; Navon, David
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ABSTRACT

Children and adult readers were compared for the degree to which they were able to avoid grapheme-to-phoneme translation in word naming, for how much they benefited from redundant phonemic information, and for the degree to which they were disturbed by minor changes in graphemes that were still phonemically appropriate. Hebrew was the target language of the study, because a change of vowel signs in Hebrew may or may not involve a change in the phonemic value of the words. Also, Hebrew readers begin reading instruction with words in which vocalic information is transmitted by vowel signs written below and above the letters, later learning to read the same words without the vowel signs. The 80 fourth grade students in the study were asked to name Hebrew words by their letters only, with the words sometimes "vowelized" correctly, sometimes either "unvowelized" or "misvowelized" in a way that either preserved or did not preserve phonemic values. When these data were compared with related data on college students, it was found that both the children and the adults were unable to resist grapheme-to-phoneme translation, that both children and adults benefited from redundant information in their normal reading, and that children, but not adults, were sensitive to minor changes in graphemes that still preserved phonemic values. (Author/RL)

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CENTER FOR THE STUDY OF READING

Technical Report No. 208

THE DEPENDENCE ON GRAPHEMES AND ON THEIR TRANSLATION TO PHONEMES IN READING: A DEVELOPMENTAL PERSPECTIVE

Joseph Shimron
University of Haifa

David Navon
University of Illinois

June 1981

University of Illinois
at Urbana-Champaign
51 Gerty Drive
Champaign, Illinois 61820

Bolt Beranek and Newman Inc.
50 Moulton Street
Cambridge, Massachusetts 02238

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Abstract

This study compares children and adult readers in the degree to which they are able to avoid grapheme-to-phoneme translation in word naming, in how much they benefit from redundant phonemic information, and the degree to which they are disturbed by minor changes in graphemes which are still phonemically appropriate. Hebrew readers begin reading instruction with words in which vocalic information is transmitted by vowel signs written below and above the letters; later on, they learn to read the same words without the vowel signs. Also, a change of vowel signs in Hebrew may or may not involve a change of phonemic value of the words. These facts were used in this study (following Navon & Shimron, 1981). Subjects were asked to name Hebrew words by their letters only. The words were sometimes vowelized correctly, and at other times they were either unvowelized or misvowelized in a way which either preserved or did not preserve phonemic values. It was found that both children and adults were unable to resist grapheme-to-phoneme translation; that both children and adults benefited from redundant information in their normal reading; and that children but not adults were sensitive to minor changes in graphemes which still preserved phonemic values.

The Dependence on Graphemes and on Their Translation to Phonemes in Reading: A Developmental Perspective

In their introduction to a recent comprehensive collection of papers on early reading, Weaver and Resnick (1979) note that despite growing knowledge of the processes involved in skilled reading, much less is known about the ways in which the reading process changes in the course of its development, and there is virtually nothing that can reliably be said about how transitions from one stage of competence to another occur. The question is whether novice readers, aside from being slower and less accurate, also attend to different features of text, make use of different reading strategies, or differ with regard to the amount of control they have on their reading processes.

In this paper we discuss the developmental trends of grapheme-to-phoneme translation in reading. We report the results of an experiment conducted on children and compare them with the results of a previous, similar experiment done with adult subjects (Navon & Shimron, 1981). The experimental paradigm and the rationale on which it was based were described and discussed in detail in Navon and Shimron. The exposition in this paper is accordingly considerably more compact than the first paper; its major concern is the developmental trend from novice to skilled readers.

A straightforward view of the reading process is that reading is a matter of translation from the visual signs of the text to the auditory elements that compose words the reader has already learned (e.g., Fries, 1962). In this conception, speech elements (although not necessarily a complete vocalization) are inevitably involved in the reading process. Huey (1908/1968) thought of inner speech as an element of all modes of reading.

An alternative model is that skilled readers may identify a written word via its visual features only, in the same way that they identify any other familiar visual pattern (e.g., Frederiksen & Kroll, 1976; Smith, 1973), or by its orthography (Chomsky, 1970). According to this view, phonemic codes are post-lexical, possibly optional, and are not derived by recoding the graphemes of the external stimulus.

Although most researchers in the field seem to lean now towards the latter model, existing experimental evidence does not rule out either of them. While many judgments of verbal stimuli appear to be insensitive to auditory confusability (Baron, 1973) or to interference by concurrent articulatory or acoustic processing (Barron & Barron, 1977; Kleiman, 1975; Levy, 1978), other judgments do seem to be affected by such manipulations (Kleiman, 1975; Rubenstein, Lewis, & Rubenstein, 1971; Baddeley & Lewis, Note 1; Perfetti & McCutchen, Note 2). On the other hand, judgments which should be based just on phonological properties are nonetheless influenced by graphemic ones (Baron, 1973; Polich,

McCarthy, Wang, & Donchin, Note 3). This may lead one to suspect that lexical entries are accessed in both ways, auditory and visual (Bradshaw, 1975; Davelaar, Coltheart, Besner, & Jonasson, 1978; LaBerge, 1972).

It may be at this point where the skilled reader differs from the unskilled one. Chomsky (1970) implied that the difference between children and adults could derive from the different principles by which their lexicon is organized. While the child's lexicon may be organized phonemically, the adult's lexicon may be more semantic in nature. If so, the skilled reader could retrieve word meaning by either visual or phonemic cues, or both, but the child is much more dependent on phonemic translation processing (cf. Smith & Kleiman, 1979). On the other hand, it has been proposed that phonemic recoding occurs more with difficult than with easy material (Edfelt, 1960; Hardyck & Petrinovich, 1970). Since what is easy for a skilled reader may be more difficult for a less experienced one, it could be hypothesized that unskilled readers will depend more on phonemic recoding than skilled readers.

In this study we will be concerned in particular with the issue of the involuntary nature of recoding a graphemic pattern into a phonemic code: Can readers successfully focus on the graphemic aspects of a word and avoid any phonemic processing, or is phonemic processing automatically done regardless of the role it plays in accessing the lexical code? And are adults and children different in this respect?

To approach these issues, we devised a sort of a Stroop task (Stroop, 1935), in which phonemic cues favor a response which conflicts with the one suggested by the relevant visual ones. For this matter we capitalized on some fortunate features of the Hebrew writing system. In Hebrew, most of the vowels are signified by small symbols printed mainly below the letters (see illustration in Figure 1). The letters, in turn, carry mostly consonantal information. The full writing

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Insert Figure 1 about here.

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system is taught in the first grades of public schools and is used mostly in prayer books, children's books, and poetry. Most of the other written materials, which will be referred to here as unvowelized, show just the letters, thus lacking a good deal of the vowel information. Children start practicing this unvowelized writing system in the second or third grade, and it is a fair estimate that at least 90% of the written material encountered by an average psychology freshman in Israel is unvowelized.

Hence, skilled Hebrew readers must be highly trained in using their knowledge of the language to complete vowel information not signified in the script while recognizing words without vowel signs, and to resolve ambiguities by bringing the context to bear. It is, thus, reasonable to assume that when asked to name single words, they will be able to tolerate the elimination of information carried by the vowel signs if it is completely redundant, that is, if the letters by themselves uniquely determine the identity of the word.

In this study we had native Hebrew speakers, children and adults, name words that were vowelized either correctly or incorrectly in a way which would lead to phonemic distortion. Subjects were instructed to disregard the vowel signs and read the words by their letters only, and were informed that there was just one admissible way to do it. Since the letter pattern of a vowelized Hebrew word seems to be a segregable, familiar unit, this seems like a reasonable requirement from a subject. If incorrect vowel signs nevertheless do interfere with word naming, this may indicate that subjects cannot help recoding the vowel signs, which in turn, interferes with lexical access or with response-generation.

To control for the possible effect of the absence of graphemic and phonemic information contained in the appropriate vowel signs, we asked another group of subjects to read words that were either vowelized correctly or were unvowelized. To control for the possibility that the effect of incorrect vowelization is just to introduce some incompatible visual cues, we presented a third group of subjects with words which were vowelized in a way which is graphemically illegal but nevertheless maps into the same phonemic categories. This was possible because native Israelis do not make all the phonemic distinctions that were historically associated with the different vowel signs, so that for each vowel there are at least two recognized symbols which are phonemically identical. Finally, it should be noted that grapheme-to-phoneme correspondence in Hebrew is very reliable and almost context-free, so in no case was there any doubt about how each vowel sign should be pronounced.

If a certain mode of misvowelization interferes with naming despite instructions to ignore the vowel signs, that would be an indication that the features it distorts are automatically processed. If, however, it is ineffective, that ineffectiveness can be due to the selective attention instructions, and may not reflect what happens in normal reading or word perception.

To see in what ways word naming under our selective attention procedure differs from ordinary word naming, we had two more groups of subjects who were not asked to ignore the vowel signs. One group was presented with words that were either vowelized correctly or were unvowelized. Another group was presented with words that were vowelized either correctly or with just a graphemic distortion.

The first group was used to determine whether in normal word recognition vowel signs that are completely redundant nevertheless facilitate naming. Comparison of adults and children would indicate whether redundancy is helpful for just unskilled readers, skilled readers as well, or neither of these types.

The second group was used to determine to what extent readers make use of detailed visual information of the sort that distinguishes between two vowel signs of the same phonemic value. If naming is inhibited by the irregular appearance of vowel signs even when they preserve phonemic values, then readers must have very good visual memory representations for words which they might use in the course of lexical access. Again,

the degree of detail in the visual memory for words or the degree of sensitivity to it might change with age and/or practice in reading.

To examine the differences between practiced and less practiced readers, we conducted two experiments that were almost identical in their method, except that one was conducted with children (fourth graders) and the other one with adults (freshman university students). The words chosen as stimuli were adjusted, in terms of familiarity, to the respective age level, consequently the results could not be analyzed in a single analysis, but the comparison of the differential patterns of the results seems to us to be quite meaningful. As said before, the data of the experiment conducted on university students has already been presented elsewhere (Navon & Shimron, 1981). Thus, we shall describe here the experiment with children, and then discuss the differential trends in the two age levels.

Method

Apparatus and setting. A Kodak Carousel slide projector mounted with a Uniblitz electronic shutter driven by a Gerbrands driver Model G1166 was used to project from the rear on a semitransparent grey screen. The projection measured 8.6 cm x 5.6 cm on the screen. The subject sat on a chair and spoke into a crystal microphone. Viewing distance was about 175 cm. A piece of cardboard served to occlude from the subject most of the screen except for a rectangular area slightly larger than the projection

area. A control box switch operated by the experimenter opened the shutter, and started the clock. The subject's vocal response stopped the clock and closed the shutter.

Stimuli. Forty-eight Hebrew nouns were used in the experiment. All words had three letters and two vowels. Only letters signifying consonants (or the null consonant[1]) were used. Vocalic information was provided by the vowel signs below the letters. The vowels could be any of the four in Table 1. The two vowel signs in either column of the table are phonemically equivalent in the common Israeli pronunciation

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Insert Table 1 about here.

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of Hebrew. The consonant pattern of each of the selected words was unique to that word; that is, there was only one reading of the unvowelized word that corresponded to an actual Hebrew word. Subjects were told of all the word properties mentioned above.

Since a word frequency list in Hebrew exists only for a very limited corpus, we ran a pre-test to assess word familiarity. That was done by recording naming latency. Words which took more than 1500 msec to name for a pilot group of 10 subjects were eliminated from the initial list. In addition, four judges who work with children of that age determined that none of the words was rare enough to make us fear that any subject would not know it. Words were presented on slides and constructed from Letraset letters and vowel symbols (Sheet No. 420). The symbols were

applied on a piece of transparent material which was then framed. Examples of stimulus words are presented in Figure 1. A typical letter subtended about .75° vertical visual angle, and a word subtended about 1.6-1.9° horizontal angle.

Procedure and design. Subjects were tested individually. A trial started with a verbal ready signal from the experimenter, followed by the presentation of the word. The subject's vocal response operated the voice-operated relay and terminated the presentation of the word. Latency and accuracy were recorded by the experimenter. Subjects were instructed to read aloud as fast as possible but with no errors.

Two demonstration trials were administered, which were used also to calibrate the sensitivity of the voice-operated relay. Then 48 experimental trials followed, in half of which words were vowelized correctly, and in the remaining half words were either unvowelized or vowelized incorrectly, depending on the experimental group.

There were two kinds of instructions. The first three groups were prewarned that the vowel signs might be invalid and that they should ignore them. They were informed that all the words could be unambiguously read even without the vowels. The remaining two groups were told that words might or might not be vowelized but they were not told to ignore the vowel signs.

As indicated above, each subject saw half of the words vowelized correctly. The manner in which he or she saw the other half of the

words (later referred to as the "incorrect" half), constituted the other between-subject variable. In these words, when vowel signs were to be disregarded, vowelization could be (a) absent, (b) graphemically distorted (but phonemically intact), by using for every vowel sign the alternative equivalent one (see Table 1), or (c) phonemically (as well as graphemically) distorted, by using for every vowel sign the one in the same row but in the other column in Table 1. That resulted in mapping every "ă" into an "e" and vice versa. Panels (B-D) of Figure 1 illustrate respectively the three transformations applied on the base word in Panel (A). For obvious reasons, there were only two modes of misvowelization in the normal reading instructions, absent and graphemically distorted.

A subject saw every word just once. Each word was presented correctly vowelized for half of the subjects in an experimental group, and incorrectly vowelized in a manner dictated by the group for the other half. Words were divided into two sets with approximately equal average familiarity. For every individual subject one set was correctly vowelized and the other one was incorrectly vowelized. For half of the subjects the first set was correctly vowelized, and for the other half the second set was correctly vowelized. Word sequences were constructed by randomly selecting the positions of the correctly vowelized words, and then using the specific words in the order in which they appeared in their word sets. Half the subjects presented with a particular sequence saw it in the original order, and the other half in the reversed order.

Subjects. Each one of the five experimental groups included 16 fourth graders (totaling 80 subjects) chosen from elementary schools in uppertown Haifa. There were about equal numbers of boys and girls in each group. All were native Hebrew speakers or had used Hebrew as their primary language for at least five years. All had normal vision.

Results

The percentage of errors in children's performance was only 1.6 in the correctly vowelized words and about 4 in the incorrectly vowelized words. Analyses of variance were conducted on correct responses only. Mean differences in latencies for incorrectly and correctly vowelized words are presented in the right panel of Figure 2 as a function of the experimental groups, separated by the instructions given to the subjects.

Insert Figure 2 about here.

Each of the analyses of variance we conducted on latency data was performed in two orthogonal ways, one with subjects as the random factor, and one with words as the random factor. In the first analysis, mean latencies of each subject in each condition were adjusted prior to analysis to reduce variability due to word sets: The deviation of mean latency for the corresponding word set from the grand mean was subtracted from the mean latency of the subject in that condition. In the second analysis, a similar procedure was used to correct word latencies for variability due to subject subgroups within each of the experimental groups.

Since the design was not completely factorial, we did not perform one overall analysis. Let us first present the data regarding the performance of children who were instructed to ignore vowel signs. The results of the two analyses (with subjects and with words as random factors) were fairly consistent. The factor of correctness of vowelization was highly significant in both: $F(1,45) = 34.8$, $p < 0.001$, and $F(1,47) = 32.61$, $p < 0.001$; respectively. When both analyses are combined, $minF'(1,92) = 16.66$, $p < 0.001$. The factor of experimental group was also highly significant in both analyses: $F(2,45) = 10.56$, $p < 0.001$, and $F(2,94) = 227.48$, $p < 0.001$. When both analyses are combined, $minF'(1,102) = 10.69$, $p < 0.005$. The interaction was also significant in both analyses: $F(2,45) = 15.09$, $p < 0.001$, and $F(2,94) = 27.61$, $p < 0.001$, respectively. $MinF'(1,138) = 9.76$, $p < 0.005$. Finer analyses were conducted to clarify the nature of the interaction.

For each subject and for each word within an experimental group we calculated mean delays due to incorrect vowelization, namely differences between their means for incorrect and correct vowelization (see Figure 2). Newman-Keuls pairwise comparisons among experimental groups indicated that regardless of whether delay scores were calculated for words or for subjects, a graphemic distortion was significantly less disruptive than the elimination of vowels altogether, and that both distortions were significantly less harmful (at the .05 level) than a phonemic distortion.

Further analyses of the differences between mean naming latencies under correct and incorrect vowelization within each group showed that the elimination of vowels did have a small effect. Although it slowed naming for only 12 of 16 subjects, $t(15) = 1.80$, $p < .10$, it slowed the reading of 32 of 48 words, $t(47) = 2.45$, $p < 0.025$. Graphemic distortion, under these instructions, slowed only 8 of 16 subjects, $t(15) = 0.9$, $p < 0.25$, and only 26 of 48 words were read more slowly than correctly vowelized words, $t(47) = 1.08$, $p < 0.25$. Thus, this treatment seems to be entirely ineffective under these instructions. The situation was entirely different with phonemic distortion, which had a highly significant effect: 14 of 16 subjects were slowed by this treatment, $t(15) = 6.05$, $p < 0.001$; and 41 of 48 words were read more slowly, $t(47) = 7.62$, $p < 0.001$.

It thus appears that under the instruction to ignore the vowels, graphemic distortion which still preserves correct vocalization had no effect, but distorting the words phonemically did slow word naming. As for the effect of the elimination of vowel signs, our data are somewhat inconclusive, but it appears that a weak effect that does not characterize all subjects does exist.

Although the percentage of errors, as mentioned above was very low, we nonetheless conducted analyses of variance on the numbers of correct responses using an arcsine square root transformation. The results were consistent with those of the analyses of latencies except that the differences were smaller. The interactions between correctness of vowelization

and experimental groups were still significant, but closer inspections of the differences within the groups showed that the only effective transformation of correct vowelization was the phonemic distortion. Hence, there seems to be no sign that speed-accuracy trade-off can account for the effects we report on latency data.

Next, the data for the two groups with no instruction to ignore vowels were analyzed together with that of the groups instructed to ignore vowels, with the elimination of the phonemic distortion condition (which could have, of course, just one kind of instruction, namely to ignore vowels). Thus, we considered the four groups as the cells of a 2 x 2 between-subject design where instructions and experimental group were the orthogonal factors. The same statistical analyses as previously reported were performed, one with subjects as a random factor, and one with words as a random factor. The relevant results were the interactions of correctness of vowelization with either of the other two factors or both.

When words were the random factor, the interaction between correctness of vowelization and instruction type was highly significant: $F(1,47) = 92.0$, $p < 0.001$. When subjects were the random factors, this interaction did not reach significance: $F(1,60) = 2.11$. Other kinds of interactions, too, approached but did not reach significance. To get a clearer picture, we proceeded with finer analyses.

Analyzing the differences between correct and incorrect vowelization within each group showed that the elimination of vowels that seemed to have a small effect when the instruction was to ignore vowels altogether, had a clearer effect without this instruction. Thirteen of 16 subjects read nonvowelized words more slowly than correctly vowelized words, $t(15) = 2.18$, $p < 0.05$, and 33 of the 48 words were read more slowly under this condition, $t(47) = 3.01$, $p < 0.01$. It thus appears that elimination of vowels did impair children's word naming under both instructions. On the other hand, graphemic distortion which had no effect whatsoever when vowels were to be ignored (see above) did have an effect in more normal reading. Twelve of 16 subjects were slowed by this treatment, $t(15) = 2.13$, $p < 0.05$; and 29 of 48 words were named more slowly in this condition: $t(47) = 2.47$, $p < 0.025$.

Thus, it appears that under more normal conditions of word perception, distortion of graphemic information, even when phonemic values were unchanged, did have a detrimental effect on the reading of children.

Once again we analyzed the number of correct responses and once again this analysis showed no sign of a speed-accuracy trade-off.

The results indicate that children behaved differently under the two instructions in the experimental conditions in which two kinds of instructions were given. Nevertheless, when vowel signs signified phonemic values which were in contrast with subjects' knowledge of these words, naming latency significantly increased. Thus, our subjects could not resist

grapheme-to-phoneme translation which was apparently not subject to voluntary control.

Having said that, as shall be pointed out below, we do not imply that translating graphemes to phonemes is the only way to get lexical access, nor even that it necessarily has an essential function in reading. We merely say that it is performed regardless of the subject's intentions.

Another interesting finding was that children benefited from presentation of correct vowel signs. Since we already indicated that grapheme-to-phoneme translation is apparently performed, the simplest explanation would be that vowel signs, even though completely redundant in words chosen for this experiment, were nevertheless an important aid that facilitated the naming process. It could also be, however, that the vowelized word is the one with which children of this age are more acquainted than the nonvowelized word with which they become more and more acquainted in later years.

That children of this age are indeed sensitive to the visual appearance of the words presented to them can be learned from the fact that graphemic distortion, which had no effect under the instruction to ignore vowel signs, did have an effect under the condition permitting a more normal kind of reading. This is in spite of the fact that these distortions made no difference with regard to the process of phonemic recoding.

Summary of Data From Adult Subjects

The experiment conducted on university students has already been described in detail elsewhere (Navon & Shimron, 1981). We are summarizing its main features and results here in short for the sake of comparison needed for discussing developmental trends.

The method of this experiment was very similar to that with the children. There were two minor differences: The number of word stimuli was 50 instead of 48. The number of subjects was 12 instead of 16 in each experimental group (totaling 60). Also some of the words differ and their selection here was done differently. Nine judges were asked to rate the frequency of each of the words on a 3-category scale (1 = infrequent; 2 = frequent; 3 = very frequent). The mean word frequency was 2.1. Nine words were categorized by at least six judges as infrequent, but none was rare enough to make us fear that any subject could not know it.

Analyses reported in Navon and Shimron (1981) were done on all latency data since errors were very rare. However, the results on similar analyses performed on latencies of correct responses only were almost identical.

Mean latencies are presented in the left panel of Figure 2 as a function of the experimental group and the instructions. Let us first consider the three groups whose instructions were to ignore the vowel signs. The results suggest that for adults, the effect of a graphemic distortion was not significantly different from the effect of elimination of vowelization altogether, and the effect of phonemic distortion was significantly stronger than that of the other two manipulations.

Moreover, the comparison of conditions within each group showed that subjects named unvowelized words with about the same speed they named correctly vowelized words. On the other hand, they were significantly inhibited by phonemic distortion. The effect of graphemic distortion was less clear. It inhibited naming of only half of the words, but three quarters of the subjects were inhibited by this treatment. ($\underline{T}$ test was significant at the .05 level.) Thus, it seems that most adults are sensitive to the irregular appearance of some of the words when vowelized in an illegal manner which nevertheless preserves phonological structure. But all of them read most words more slowly when vowelized in violation of phonological structure.

Now we will compare the results of the subjects who were instructed to ignore vowel signs and those who were not, in the unvowelized and in the graphemic distortion conditions.

A three-way interaction between instructions, correctness of vowelization, and mode of misvowelization was found significant with subjects and with words, but not when both analyses were combined. Finer analyses indicated that whereas there was no effect of unvowelization under instructions to ignore the vowel signs, such an effect was present for both subjects and words, under instructions to read as usual. On the other hand, a graphemic distortion seems not to have any effect whatsoever on naming, at least under normal naming instructions.

Thus, the data suggest, although not conclusively, that when vowels were not ignored, the absence of vowels is disruptive, but their graphemic distortion is not so.

The most important conclusion that was drawn from these results is that vowel signs facilitate word recognition, at least in the case of an isolated word, even when they do not add any information beyond that contributed by the letters. This is particularly interesting in view of the vast exposure of practiced Hebrew readers to unvowelized texts. Thus, this is a demonstration that advantages of redundancy may not vanish with extensive practice. In view of our other results, it seems that the advantages are primarily phonemic.

The differential effectiveness of the elimination of vowel signs indicates that adult subjects were also able, to some extent, to disregard the vowel signs when asked to do it. Yet, at the same time, it is clear that adult subjects are, by and large, insensitive to a graphemic distortion of the kind we used. This strengthens our belief that the effect obtained with the treatment which we called phonemic distortion was indeed due to phonemic interference.

Discussion

Let us summarize first the conclusions which can be drawn from the results of both experiments reported here and in Navon and Shimron (1981) about the general question of phonemic recoding in reading. Then we shall consider the issue of developmental level on reading skill.

The results indicate that to-be-ignored vowel signs which are incompatible with the phonological structure of a word slow down one's ability to read the word aloud.

That this is not due merely to the absence of the appropriate vowel signs is evidenced by the significant difference between the effect of phonemic distortion and that of the absence of vowel signs. That these results cannot be solely attributed to the deviation of the pattern of the incorrectly vowelized word from its familiar shape is suggested by two findings: (a) A similar transformation which was merely graphemical was significantly less harmful than the one that had phonological implications, and (b) it was actually no more harmful than elimination of vowel signs altogether. The remote possibility that the latter qualitative difference was caused by a greater visual distortion associated with transformations meant as phonemic, was further ruled out by the results of another experiment reported by Navon and Shimron (1981), in which subjects had to sort symbols containing inverted vowel signs: Vowel signs which map onto the same phoneme were not sorted more slowly, thus were probably not more visually similar to each other than vowel signs which represent different phonemes.

One might conjecture that intact words are recognized without any phonemic mediation, and that grapheme-to-phoneme rules are invoked only when words are distorted. Of course, some graphemic distortions may be sufficiently grave to render phonemic recoding indispensable. However,

the finding that a mere graphemic distortion had no inhibitory effect suggests that graphemic distortions of the kind used in this study could not induce a qualitative change in the mode of processing.

Thus, the interference is probably phonemic. That is, at least on part of the trials, vowel signs were encoded and phonemically recoded. That suggests to us that, in general, graphemes are automatically translated into phonemes, although we cannot decide the locus and role of that process of translation: it may take place before, after or in parallel with lexical access. For more detailed discussion and interpretations of these findings, the reader is referred to Navon and Shimron (1981).

We turn now to the developmental issues. In spite of instructions to ignore vowel signs, both children and adults were significantly disturbed when vowel signs were incompatible with the phonemic code of the words. As pointed out above, there was a reason to expect that recoding would be one dimension of developmental change, so that the more skilled the reader, the less he/she would depend on it. Observing Figure 2, one can see that, indeed, children seemed to be more interrupted by phonemic distortions; however, even adults were significantly slowed down by it. Thus, the question posed by Weaver and Resnick (1979) of whether the processing models of children and adults are qualitatively different in that the two groups may behave differently in reading, cannot be answered affirmatively in considering this study.

Another finding of particular interest is that both children and adults took advantage of vowel signs under the condition more similar to normal reading. Children showed that even under the instruction to ignore vowels, the presence of correct vowelization was sometimes facilitative. Such a facilitation is not surprising for children, but it is more so when found with skilled adult readers. Since adult Hebrew readers are quite accustomed to nonvowelized script, it was not clear a priori that introducing vowel signs that were completely redundant would have a considerable effect.

It could be said that this study further supports the contention that some redundancy speeds up processing (e.g., Garner, 1974), and that in this particular regard, children and adults are not different from each other. We should be cautious, however, with this conclusion. It could be that the facilitative effect of vowel signs on children and on adults is not the same.

The facilitation exerted by vowel signs (or the lack of inhibition from their absence) could arise out of at least two sources. One, the vowel signs may provide phonemic information that may aid lexical access, response generation, or both. In this case, it should not matter whether the vowel signs are graphemically correct as long as they provide the correct phonemic information. This seems to be the case with the adult subjects. Another possible source of facilitation is visual in nature. If the vowel signs are part of the representation of the word in the

mental lexicon, then both their absence and their replacement with any graphemically different signs should be inhibitory. This perhaps is the case with children. Under conditions more similar to normal reading, graphemically distorted words did not cause longer latencies than correctly vowelized words in adults, but they did so with children. It may be that because adults are more practiced or because they are exposed more to unvowelized texts, their visual memory of the appropriate vowelization plays a small role in their reading. This was obviously not the case with children who showed that they were definitely sensitive to graphemic distortions in normal reading.

It is, thus, quite possible that the benefit children gain from presentation of properly vowelized words, compared with graphemically distorted or nonvowelized words, is twofold: It may help them to extract the phonemic value of the words, and it also is more efficient in activating the word image stored in their memory.

In sum, we have presented some evidence that when written Hebrew words are being named by both children and adults, their graphemes are phonemically recoded, but that effect is more pronounced in children. Vowel signs which were completely redundant for naming the words were nevertheless found to be facilitative in both children and adults. It was, however, suggested that the causes for that facilitation were partly different for children and adults: Children appeared to be more sensitive to distortions which were just graphemic and which map onto

the same phonemic code. Thus, perhaps for children, unlike adults, correct vowel signs facilitate not only phonemic recoding but also lexical access via the visual route.

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Footnote

[1]A vowel with no consonant (such as at the beginning of the English word egg) is marked by a letter with no consonantal value of its own vowelized with the appropriate vowel sign (see the rightmost letter of the third word in Figure 1).

Table 1

The Forms, the Names and Approximate Pronunciations

of the Vowel Signs Used in Experiment 1

	Rough Phonemic Equivalent in American English	
	ä as in "cart"	e as in "less"
Form	□	□
Name	◌ָ kamatz	◌ֶ segol
Form	□	□
Name	◌ַ patah	◌ֵ tsere

Note: A hollow square stands for any Hebrew letter.

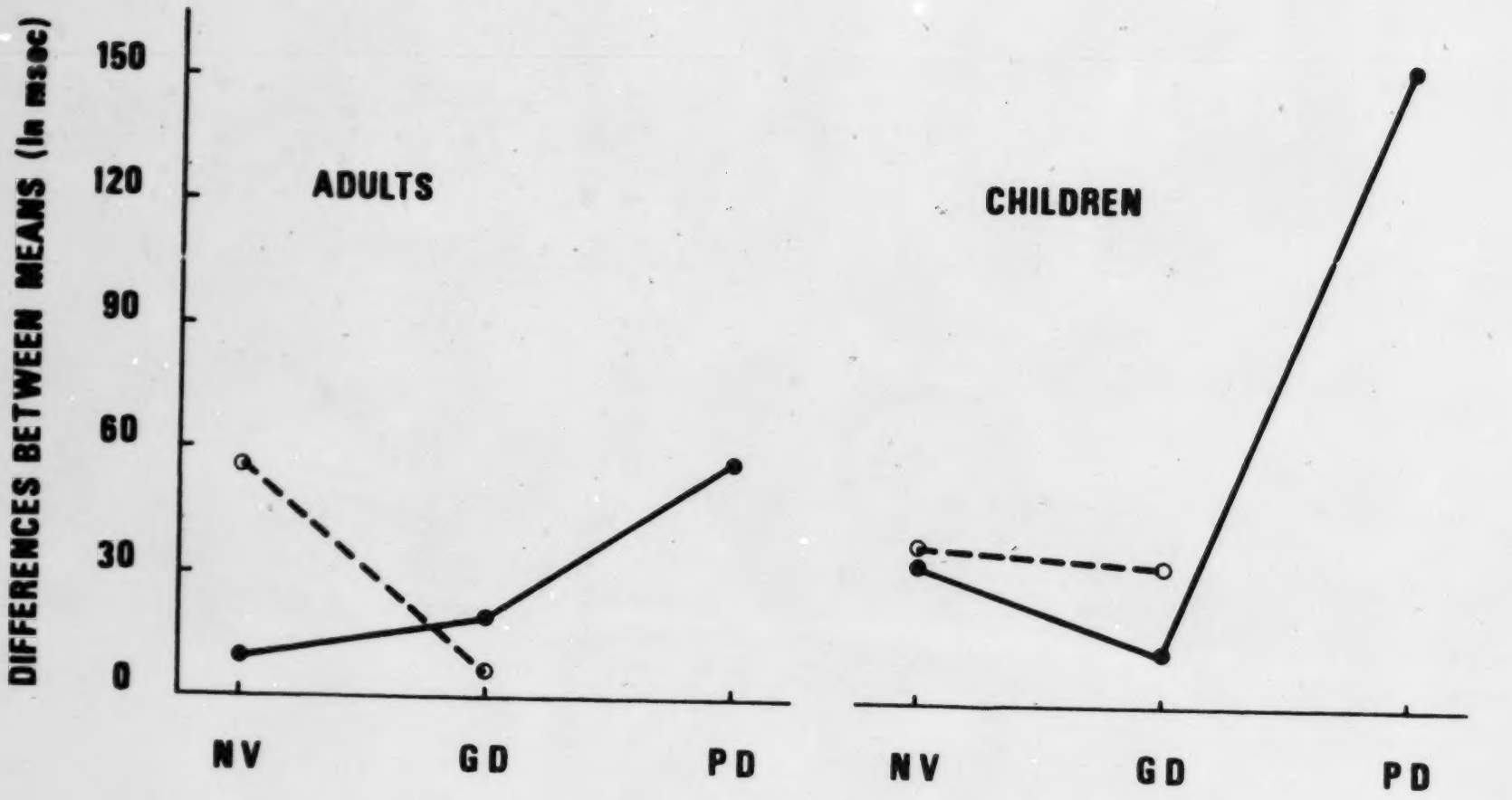
Figure Captions

Figure 1. Four examples of stimulus words as they appeared in the experiment under four conditions: (A) correctly vowelized; (B) unvowelized; (C) graphemically distorted; (D) phonemically (and graphemically) distorted. The pronunciations of the words and of their phonemic distortions are: metzäkh - mätzekh; sheleg - shäläg; äggäs - egges; khätzer - khetzär.

Figure 2. Mean differences of naming latency (in msec) as a function of the manner by which the word is vowelized: vowelized correctly vs. either unvowelized (NV), graphemically distorted (GD), or phonemically distorted (PD); under the instruction to ignore vowel signs (solid lines) or to name in the normal way (broken lines) in children and adults.

(A)	(B)
מַצַח	מצח
שֶׁלֶג	שלג
אַגָם	אגם
חָצִיר	חציר

(C)	(D)
מָצָח	מַצַח
שֶׁלֶג	שָׁלָג
אָגַם	אֲגֻם
חָצִיר	חֲצַר


DIFFERENCES BETWEEN MEANS (In msec)
150
120
90
60
30
0
ADULTS
CHILDREN
NV
GD
PD
NV
GD
PD
MODES OF VOWELIZATION

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